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COPLANAR POLYCHLORINATED BIPHENYLS (PCBs) IN A NATIONAL SAMPLE OF BEEF IN THE UNITED STATES: PRELIMINARY RESULTS

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1. INTRODUCTION

The purpose of this paper is to report on the preliminary results of the concentrations of coplanar polychlorinated biphenyls (coplanar PCBs) in a statistical sample of beef back fat in the United States. These coplanar PCBs were measured in the samples: PCB 77, PCB 118, PCB 105, PCB 126, PCB 156, PCB 157, PCB 169. The beef samples came from a previous national survey for chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs) in United States beef animals[1]. This study was a joint effort of the United States Department of Agriculture (USDA) and the United States Environmental Protection Agency (EPA). The analytical procedures for the coplanar PCBs in these back fat samples are detailed in Ferrario, et al[2].

2. BACKGROUND

The primary objective of the national statistical study was to estimate the rate of occurrence and concentration of 2,3,7,8-substituted congeners of CDDs and CDFs in the back fat of beef animals sampled from federally inspected slaughter establishments. Analysis of these same samples for the coplanar PCBs now extends that primary objective to these additional compounds which have a quantifiable measure of dioxin toxicity[3]. Study design features included the classification of major bovine classes, development of a sampling frame (i.e., a listing of eligible slaughter establishments and the bovine classes slaughtered in them), and the random selection of slaughter establishments. This random selection included, for each establishment, the animal class(es) and the number of animals per class to be sampled from that establishment.

The initial sample size was 65 animals. This size was limited principally by funding

constraints. The number of individual carcasses sampled per animal class was based on the proportion of each animal class to the total beef production in the United States in 1993. This resulted in the collection of the following samples: 2 bulls, 33 steers, 18 heifers, 6 dairy cows, and 6 beef cows. Only one bull should have been selected based on proportionality, but another design criteria was that at least two animals per slaughter class be selected. With this exception, all animals in the final sample have essentially the same statistical weight. In a statistical sample where all members of the population have the same weight, extrapolation to the represented population can be achieved by simple analysis of the samples themselves, without any adjustment for survey weights. After sampling of 65 animals, two dairy cow samples were rejected because the samples were mostly comprised of sinewy (i.e. connective) tissue and not back fat. It was decided that sinewy tissue did not meet the operational definition of adipose tissue in that it only contained approximately 1% (by weight) lipid. Therefore, in the national extrapolation of the results for CDDs/CDFs, the samples were weighted to reflect both the reduction in the dairy cow samples and the addition of the one bull sample[1].

Back fat was selected for sampling for these reasons: 1) it was a fat reservoir readily available to USDA veterinary medical officers (who did the sampling) at the slaughter establishments, 2) as a fat reservoir (the average lipid content was about 90%), it was expected that concentrations of the dioxin-like compounds would be higher than other reservoirs in the body containing less fat. Therefore, chemical analysis would more likely be able to quantify concentrations, 3) although back fat is not used directly for human consumption, it is located in the loin area and is an extension of a fat reservoir which is the outer fat layer of rib cuts of beef, and 4) the expectation is that concentrations in back fat are the same as fat concentrations in edible fat reservoirs in the cattle.

Approximately 230 g of back fat were taken for each sample. The samples were collected during May and June, 1994. Following analysis for CDDs and CDFs in August through October of 1994, the remainder from each sample has been kept frozen at -70°C until recently retrieved for analysis of the coplanar PCBs.

3. RESULTS

Table 1 shows a summary of the preliminary results from this analysis. These concentrations are lipid adjusted. It is important to understand that these results do not represent the national extrapolation to coplanar PCBs in beef fat. That analysis is currently underway. However, rigorous statistical extrapolation is not expected to greatly change this summary since the departures from absolute randomness in sampling were minimal. As discussed above, these departures included an additional bull sampled and rejection of two dairy cow samples.

Ferrario, et al.[2] discussed the ubiquitous presence of the coplanar PCBs, leading to their occurrence in blank as well as matrix samples in numerous studies. In order to conclude that the coplanar PCBs measured in the beef fat were truly in the beef fat matrix rather than inadvertently introduced during the analysis of the samples, the following was done. Concentrations of the congeners in 16 method blanks were first determined. Then, the average concentration plus two standard deviations was subtracted from the concentration found in the beef fat in every sample. Finally, Ferrario et al.[2] determined congener-specific limits of detection (LODs) and quantitation (LOQ), which were defined as the lowest reliable concentration in the matrix after this subtraction procedure. These LOD/LOQ values are provided in Table 1.

Except for PCB 77, these compounds were found to be present in beef fat at occurrence frequencies greater than 85%. PCB 77 was found in only 19% of the samples. The concentrations found in this study are comparable to those found in grocery store samples of beef in Finland[4]: 1) PCB 77: 0.13 ppt in Finland compared to 0.58 (ND=0) and 0.98 (ND=½ LOD) ppt found in this study, 2) PCB 105: 22 ppt compared to 92.7/91.8 ppt, 3) PCB 126: 3.2 ppt

compared to 4.1 ppt, and 4) PCB 169: 0.5 compared to 0.70/0.69 ppt. These samples from Finland were not lipid adjusted. Grocery store beef would be around 15-25% fat, so the Finnish concentrations would need to be multiplied by about 5 to be on the same lipid basis as the results from this study. The toxicity equivalency factors (TEFs) listed in Table 1 were those determined by the World Health Organization[3]. The toxic equivalent concentration (TEQ) for each congener listed in Table 1 was determined simply by multiplying the average concentration, with ND = ½ LOD, times the TEF. A summation of the TEQ concentrations for the 7 PCB coplanar congeners equals 0.51 ppt. The TEQ concentration at ND = 0 is virtually identical. The congener most responsible for this TEQ concentration is PCB 126, whose TEQ concentration is 0.41 ppt. The 0.51 ppt TEQ concentration of coplanar PCBs (lipid based) is quite comparable to the 0.89 ppt TEQ of dioxins/furans (ND=½ LOD) and 0.39 ppt TEQ (ND = 0) found earlier in these beef back fat samples[1].

4. UNCERTAINTIES

When interpreting the results of this national survey of coplanar PCBs in fat, the following uncertainties should be regarded:

1. Although internally reviewed by US EPA, these data have not yet undergone external peer review. Also, and as discussed above, the simple averaging done for this paper does not reflect national extrapolation.

2. The survey measured CDD, CDF, and coplanar PCB levels in back fat samples collected from slaughter establishments. Extrapolation to dietary fat should be done cautiously. The following should be considered: 1) levels of these compounds may decrease or increase after the beef or beef products leave the slaughter establishment. These changes could occur as a result of commercial operations such as packaging, processing, shipping, and handling, or consumer practices such as handling, trimming and cooking, and 2) it is presently uncertain if CDDs, CDFs, and coplanar PCBs partition equally to all fat compartments in cattle and dairy cows.

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Table 1. Summary of coplanar PCBs in a statistical sample of beef fat in the United States.

Description	PCB 77	PCB 118	PCB 105	PCB 126	PCB 156	PCB 157	PCB 169
Number of samples	63	63	63	63	63	63	63
LOD/LOQ; Limits of Detection/Quantitation, ppt[1]	1.00/1.00	30.0/30.0	15.0/15.0	0.4/0.4	14.0/14.0	1.0/1.0	0.2/0.3
Percent positive	19	100	87	100	100	98	94
Mean, ppt							
ND = ½ DL	0.98	448.6	92.7	4.1	60.7	13.8	0.70
ND = 0.00	0.58	448.6	91.8	4.1	60.7	13.8	0.69
Range, ppt	ND-7.97	61-2294	ND-437	0.7-21.2	4.9-426	ND-91.7	ND-2.4
Toxicity Equivalency Factor, TEF[2]	0.0005	0.0001	0.0001	0.1	0.0005	0.0005	0.01
Toxic Equivalent Concentration, ppt	$4.9*10^{-4}$	$4.4*10^{-2}$	$9.3*10^{-3}$	$4.1*10^{-1}$	$3.0*10^{-2}$	$6.9*10^{-3}$	$7.0*10^{-3}$

[1] See Ferrario, et al[2] for more information on analytical procedures.
[2] See Ahlborg, et al[3] for a discussion of toxicity equivalency of coplanar PCBs.